EuroMeSCo policy brief

No. 64
1 September 2016

THIS IS (NOT) ROCKET SCIENCE: USING SPACE-BASED SOLUTIONS FOR MORE SUSTAINABLE MANAGEMENT OF WATER RESOURCES IN JORDAN*

Mikołaj Janowski, Karolina Jaworska, Krzysztof Kanawka, Michal Moroz, Agnieszka Rybaczyk, Katarzyna Sidło[1]

Introduction

With the annual renewable freshwater resources per capita amounting to 133.7 CM (cubic metres) – way below the global average of 6,000 CM and significantly less than the water poverty line of 500 CM (AQUASTAT) – Jordan is the second most water scarce country in the world. High population growth, climate changes and rising agriculture demands are further depleting those already limited reserves. Furthermore, the constant refugee influx from Iraq and Syria adds to the burden on Jordan's water resources system and creates additional discords between the refugees and native population. Other factors contributing to the worsening of the situation are illegal wells, pipeline water theft, groundwater exploitation, and technical water loss.

Should these trends continue, it is estimated that by 2025 the renewable freshwater resources will shrink even more (below 100 m^3 / per capita / per year) (USAID, 2014).

Both the government and the King of Jordan are painfully aware of this situation. The influx of Syrian refugees to the kingdom, which significantly sped up the process of water depletion, seems to have prompted more decisive actions on the part of the rulers. At the beginning of 2014, the Ministry of Planning and International Cooperation, in cooperation with a number of other ministries, published the National Resilience Plan (NRP, 2014), aiming to address the challenges in response to the impact of the civil war in Syria on Jordan. The Plan allows fast-tracking of the implementation time of many critical projects aiming to alleviate the situation of hundreds of thousands refugees and host

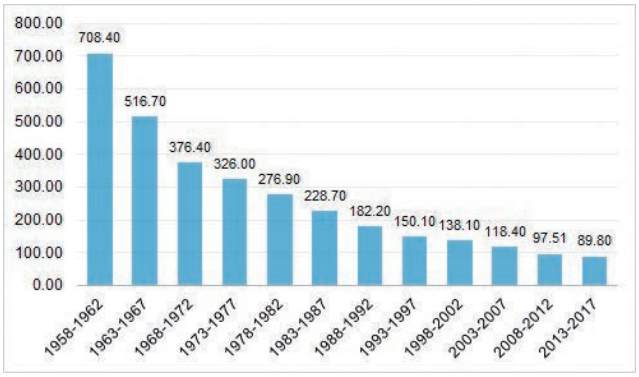
* The present paper presents the results of a study conducted between 2014 and 2015 within the Space for Mediterranean (SpaceForMed) framework led by the European Space Agency and European Investment Bank. Currently (July 2016), the results are being consulted with the Polish Space Agency (POLSA) in order to create a commercial product as a follow-up of the project. The solution is also being considered for development through the Oasis500 accelerator.

1 Mikołaj Janowski, Project Specialist, Kosmonauta.net; Karolina Jaworska, Project Specialist, Kosmonauta.net; Krzysztof Kanawka, Chief Executive Officer, Blue Dot Solutions; Michal Moroz, Chief Analytics Officer, Blue Dot Solutions; Agnieszka Rybaczyk, Project Specialist, Kosmonauta.net; Katarzyna Sidło, Political Economist, CASE – Center for Social and Economic Research

IEMed.

populations alike. It sets the financial framework and modes for cooperation, and as such is the prime guideline for cooperation between the ministry and business community.

Figure 1: Total internal renewable water resources per capita (m^3/inhab/year)



Source: Own production based on FAO data AQUASTAT

However, water-related issues are only one portion of what the NRP covers. What really set a roadmap for the government and non-governmental entities alike in terms of water management was Jordan's Water Strategy (JWS) 2008-2022. Drafted to improve water conditions, the document covers several recommendations that aim to monitor water flows and leaks, better allocation of water sources, expansion of the water infrastructure, and improvement of water treatment procedures. Moreover, tariffs and customs duties removal is recommended in order to make imported agricultural products more competitive, and to limit water-intensive domestic production and as a result – the water demand in agriculture. The strategy also envisages a bigger role for the private sector. It suggests that the scale of wastewater treatment should be expanded, and treated water should be utilised, for instance, in agriculture, tourism (landscaping) and industry. Additionally, water quality is to be monitored more vigorously.

JWS also aims to reduce Non-Revenue Water (water that is lost before reaching the customer) to 25% by 2022, with technical losses accounting for no more than 15%. To achieve this goal JWS stipulates that rehabilitation of the water supply network is necessary, a process that would require improvements in planning, more efficient operation and maintenance, and stronger technical, managerial and financial capacities of concerned departments. Moreover, the plan underscores the need for private sector participation. It also recognises the problem of illegal water use, and stresses the need to tighten control over water extraction and stricter enforcement of the existing laws. Creation of new bylaws aimed at closing illegal water use was also planned.

These ambitious plans should by now be halfway through their implementation. Alas, the worsening political and security situation in the region, slow pace of adjusting existing laws, as well as the rather surprising lack of urgency on the part of bureaucrats of various levels, significantly slow the process down. Sadly, these issues cannot be fixed by any kind of technology, even space-based ones. However, many other water-management related problems can, and in our opinion should, be solved through using some of the space-based, yet widely available, solutions, such as satellite-based integrated applications (e.g. by linking Earth Observation, Global Navigation Satellite Systems, meteorological imagery or satellite telecommunications).

New Water Management Service Opportunities Identified

The use of space-based technologies seldom seem to have been considered by both the Jordanian government and the international bodies such as the United Nations thus far, with most relevant projects conducted on a university level. This is rather unfortunate, as the relevant technology is readily available and increasingly affordable and, as we argue below, can be applied in many different ways to solve various problems related to water management. It is also encouraging that the 2014 NASA-led MENA WSIP study results were received with interest by the Jordanian decision-makers.

The most pressing issues discussed below were identified during the course of consultations conducted with the stakeholders in December 2014, preceded by desk research. Needless to say, this selection is by no means exhaustive. Rather, it covers the issues that had the potential to be solved with the use of satellite-based technologies in a relatively straightforward, thus easy to implement (up to two years), and sustainable way.

Sewage Water Transport Monitoring

In many areas throughout the country – outside the bigger cities like Amman – sewage infrastructure is not sufficient or outright non-existent. Where it does not exist (roughly in 1/3 of the cases), special trucks are being used to transport wastewater to sewage treatment plants. It appears[2] that a significant proportion of these trucks never reaches their proper final destination, however, and they dump the wastewater into random desert areas instead, polluting underground reservoirs. The control system that is currently in place, requiring drivers to obtain a signature from the treatment plant facilities confirming that sewage was delivered, is easily rigged; the signatures can be quite easily forged or

2 Although no estimates of this number are available since there is no direct indication of the problem in official documents (e.g. neither NSWMP nor the Action Plan for Implementing the Strategy [2009–2022] for Water Sector mention it at all) or other kinds of publicly available sources of information, as it became clear during the on-spot interviews, it is common knowledge that this problem exists and that its scale is not insignificant.

the persons that are supposed to place them can be bribed. As a result, large volumes of wastewater end up being dumped illegally (and mostly undetected) across the country, adversely affecting both the environment and local communities; causing soil and groundwater contamination, as well as limiting the amount/percentage of treated water.

The suggested solution involves employing Earth Observation systems instead of people to monitor the transportation and discharge process. The execution of this solution would of course require some amendments in the local laws. For instance, financial penalties for illegal sewage dispatch would have to be assigned and, more importantly, enforced.

Water Quality Monitoring in Eastern Jordan

Not only the quantity but also the quality of water (both surface and groundwater) available is a major issue in Jordan, and the quality monitoring tools are not consistently used all over the country. This is especially true in more remote, eastern parts of Jordan, where water reservoirs situated next to dams are not subjected to any regular quality tests due to the long distance and low priority given to them. At the same time, these reservoirs are used by local, mostly Bedouin, populations, who treat them as a drinking water source.

This problem could be quite easily solved using the Earth Observation images to remotely search for signs of water quality changes in remote areas, where tests are rarely performed. Should a suspected pollution area be identified, a specially trained employee would be sent to the area to conduct additional tests and report their results further to the responsible authorities. The technology necessary to implement this solution is easily accessible – for instance the satellite imagery data of sufficient quality could be obtained from European Sentinel 2 satellites. The additional benefit of these solutions is that local experts, as well as scientists and students from Jordanian universities, could be quickly trained to operate the system, and its implementation does not require significant changes in the existing legislation.

Water Pipeline Leak Monitoring

The Jordanian Ministry of Water and Irrigation estimated in 2012 that water losses on average account for 41% of the total amount of water that Jordanian Water Authority pumps to the water network every year (Ministry of Water and Irrigation, 2012). Waterworks leakages – apart, obviously, from causing major water waste – also adversely affect the environment in other ways. Compensating for water losses through increased water extraction requires additional energy, which as a result contributes to higher greenhouse gas emissions, not to mention the costs it generates for the not-so-balanced Jordanian budget. Despite the gravity of the problem (as well as its being acknowledged by the

A typical water seepage (Source: scirp.org)

government), no sustainable, comprehensive water monitoring system, which would cover and tackle all of Jordan's water losses, exists in the country.

Space-based technology could also quite easily be employed to fix this problem. Moist sand (which typically would appear in case of water pipe leaks in a desert terrain like Jordan) is clearly distinguishable from dry, as already proven by various research projects using satellite imagery.[3] Earth Observation images could therefore be used to search for any signs of spillage (i.e. wet sand colour), as well as to detect plants and other chlorophyllic organisms that are usually present in the area of the leakage. Should a leak anywhere in the waterworks be suspected (although, admittedly, the system would work better outside of the cities and in general areas filled with concrete), a specially trained inspector would be sent to survey the problem on the spot and communicate the results to the responsible authorities. Such communication would involve, among others, geographical coordinates of suspected leak sites for investigation that would be inserted into a database for future reference.

This solution would require the purchase of specialist equipment and training of a dedicated developer team. Moreover, due to fast evaporating times the necessity arises to purchase rather pricey additional imagery supplemented from commercial satellite imagery providers. That said, the resulting savings in both water, energy and operational costs could in the long run make up for these expenditures; the total revenue loss of the Jordanian Water Authority was calculated to amount to 130 million EUR per annum and energy consumption is the biggest single cost in its yearly budget (MWI, 2012).

Water Theft Monitoring in Agriculture

Pipeline leaks are not the only reason for significant water losses that Jordanian water authorities are suffering. Water theft is another major issue. In fact, according to the Ministry of Water and Irrigation, in 2013 70% of water loss in Jordan was due to theft and illegal usage. Illegal water wells – the number of which in 2012 was estimated to stand at 1,381 – were evaluated to amount to 40% of the total water wells use (MWI, 2012). Although

3. See Hadjimitsis, D.G., Agapiou, A., Themistocleous, K., Toulios,G., Perdikou, S., Toulios, L., & Clayton, Ch. (2013, July 10). Detection of Water Pipes and Leakages in Rural Water Supply Networks Using Remote Sensing Techniques. In D. G. Hadjimitsis (Ed.), *Remote Sensing of Environment - Integrated Approaches.* InTech. DOI: 10.5772/39309

other entities such as Mercy Corps (2014) quote more moderate numbers – according to them, 30% of water pumped in Jordan (i.e. 190 million m^3) is lost each year due to theft and 20% is due to leakages – it might still be safe to assume that Jordan loses a whopping one third of its water supplied because of illegal activities.

The suggested solution would involve the use of satellite images to scan agricultural areas. The images obtained would subsequently be compared with the official water access databases (such as maps of official water wells and pipeline networks); should crop cultivation areas be identified in places where they theoretically, due to the lack of sufficient official water infrastructure, could not exist without illegal access to water resources, a specialist team would be sent to survey the situation and report the results further to the responsible authorities.

Again, although the solution is quite straightforward on the technical side (utilising Geographic Information System workstations at a Service Centre connected to a data server), its implementation may face significant obstacles at the social and cultural end. Due to tribal sensitivities, and a seemingly widespread belief that one cannot steal a common good such as water,[4] the probability that local communities in Jordan will help to localise or stop using illegal water access points is slim. Secondly, the areas targeted most severely by the inspectors might depend on the political clout and connections of particular tribes and clans, otherwise known in Jordan as *wasta.* Thus, one needs to take into consideration that there is a possibility that this system would be used to show that the water is "stolen" by incoming refugees, or tribes and clans in conflict with the government.

Integrated Water Access Database

Despite water management being one of the most pressing issues in the country, Jordan lacks a single integrated database containing all relevant information, such as access points, pipelines or flow analyses. Although all the data is theoretically obtainable from various government bodies, the process is complicated and time consuming, and can postpone the implementation of the ongoing projects – as well as drafting of the new ones – for additional weeks or even months. A software solution showing all wells, pipelines and other water access points (both legal and illegal) in one place would be highly beneficial for water infrastructure construction companies and those involved in water infrastructure monitoring projects. Creation of such a database would additionally allow for checking of the current data for errors, as well as searching for any data deficiencies.

4 Which might have its source, even if not on the conscious level, in the famous hadith (tradition) of the Prophet Muhammad in which he states that certain goods – water, fire and grass – are supposed to be freely accessible to all members of the Islamic community, or *ummah,* and thus should not be charged for.

The idea in itself is not new, it has already been suggested, for example, by the German Development Agency (GIZ). What is innovative is the use of a GNSS-based mobile service, where specially trained teams would geo-tag any existing identified issues. This way, the database would include all the data on the local terrain parameters (such as topographic, digital elevation models, as well as aerial and free available satellite maps), and – as all registered users could have a chance to send inputs (e.g. information on an illegal water access point) that would subsequently be verified and put into the database by an administrator – extensive water network registers.

The most challenging part of this project concerns integrating the data already available from different sources, as the process may cause long delays at the inception of the project. Consequently, additional supervision from an external funding entity would be strongly recommended. Even more importantly, a high level of involvement on the part of the government would be necessary to safeguard a decent pace of the implementation of all the necessary procedures.

Roadmap and Conclusions

As has hopefully been shown, much can be gained by implementing integrated satellite applications into water management in Jordan. In money terms, each cubic metre of water saved means budget savings for the government. Moreover, successful implementation of any of the proposed solutions could have a positive influence on the public perception towards the water utility companies and water authorities in general, which in turn might increase the consumers' willingness to pay their water bills. This would further alleviate the budget of WAJ and its subsidiaries, allowing them to invest more in new remedial and development projects.

However, the advantages go beyond measurable dimensions, such as cubic metres of water or amount of Jordanian dinars saved. Implementation of any of the space-based water applications provides numerous possibilities for engaging the local population in the sector of innovative technologies. It may stimulate an entrepreneurial spirit allowing for job creation and partly ease pressure among young ambitious graduates leaving Jordanian schools each year. The growing number of highly skilled specialists would constitute a further asset for the Jordanian economy and contribute to its sustainable development. It would also provide an opportunity for local and international contractors involved in water network monitoring, as well as its upgrade and maintenance, to invest in the country.

The condition *sine qua non* for the implementation of any of the above described solutions is of course the dedication and high levels of involvement on the part of government

officials and administration. A lot of political will and determination will be needed to force relevant changes in the existing laws, secure funds in the budget to pay for portions of new projects, and secure funds from prospective investors, not to mention facing the discontent and opposition from the groups whose immediate interests will be at stake (consider, for instance, farmers illegally extracting water or communities using unregistered wells).

But even that will not be enough. The government will also need to convince the general population that changes in water management are necessary. Indeed, no solution on its own will do without a shift in societal attitudes; currently, an average Jordanian does not behave like a resident of the second driest country in the world. A view of water leaking abundantly from a *barbeesh* (hose) left to its own devices on the ground or a restaurant employee watering a tiny lawn outside of a building for the better part of an hour is not as uncommon as one would wish. Social campaigns raising the levels of awareness about the importance of saving water are therefore an absolute must, especially that the upgrading of the water network and improvements in monitoring will come at a cost, as they may require temporary water cut-offs for the duration of upgrade and/or water leakage tests. The public may need to get ready for possible increases in water tariffs, necessary to at least partially cover the costs of network maintenance and modernisation schemes.

Jordanians should also be educated on the usefulness and seemingly paradoxical down-to-earthness of the space-based solutions. In an environment where the most basic needs are often not met, suggestions of using advanced technologies perceived as high cost to solve even the direst problems, such as water shortage, may, rather understandably, face distrust and scepticism (not only among the general population but some of the government officials and other relevant stakeholders). The public should therefore be informed about how the satellite-based services can contribute to more efficient spending of public funds.

References

AQUASTAT-FAO's Information System on Water and Agriculture. Retrieved from www.fao.org/nr/aquastat/

GIZ. (2011). *Guidelines for Water Loss Reduction: A Focus on Pressure Management.* Retrieved from http://www.giz.de/fachexpertise/downloads/giz2011-en-guideline-water-loss-reduction.pdf

Mercy Corps. (2014). *Tapped Out: Water Scarcity and Refugee Pressures in Jordan.* Retrieved from http://www.mercycorps.org/sites/default/files/MercyCorps_TappedOut_JordanWaterReport_March204.pdf

Ministry of Planning and International Cooperation. (2014). *Final Draft National Resilience Plan 2014-2016: Proposed Priority Responses to Mitigate the Impact of the Syrian Crisis on Jordan and Jordanian Host Communities.* Retrieved from http://static1.squarespace.com/static/522c2552e4b0d3c39ccd1e00/t/53f300ffe4b082b86e9e72bd/1408434431620/NRP_FinalDraft_June2014.pdf

Ministry of Water and Irrigation. (2009a). *Action Plan for Implementing the Strategy (2009-2022) for Water Sector.* Retrieved from http://www.mwi.gov.jo/sites/en-us/Downloads/ActionPlan.pdf

Ministry of Water and Irrigation. (2009b). *Water for Life: Jordan's Water Strategy 2008-2022.* Retrieved from http://foeme.org/uploads/Water_Strategy_09_Jordan.pdf

Ministry of Water and Irrigation. (2012). *Annual Report.* Retrieved from http://www.mwi.gov.jo/sites/en-us/Annual%20Reports/MWI%202012%20English%20Report.pdf

USAID. (2014). *Institutional Support & Strengthening Program: National Strategic Wastewater Master Plan Final Report.* Retrieved from http://isspjordan.org/files/upload/resources/887b1bd5c49d87e23fbf18201db3326c.pdf

IEMed.

This publication has been produced with the assistance of the European Union. The contents of this publication are the sole responsibility of the author and can in no way be taken to reflect the views of the European Union or the European Institute of the Mediterranean